SCIENCE

NEW SERIES
VOL. XLV. No. 1162

FRIDAY, APRIL 6, 1917

SINGLE COPIES, 15 CTS.
ANNUAL SUBSCRIPTION, $5.00

SCIENCE

Friday, April 6, 1917

CONTENTS

MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-On-Hudson, N. Y.

RADIATION AND ATOMIC STRUCTURE[1]

While the study of the physical and chemical properties of matter has produced our present atomic theory and furnished most of the information which is available about the way in which the myriad molecular structures are built up out of their atomic constituents, it has been chiefly the facts of radiation which have provided reliable information about the inner structure of the atom itself. Indeed, during all the years in which the dogma of the indestructible and indivisible atom was upon the stage, it was the complexity of the spectra even of simple gases which kept the physicist in the path of truth and caused him continually to insist that the atom could not be an ultimate thing, but rather that it must have a structure, and a very intricate one at that—as intricate, in Rowland's phrase, as a grand piano.

Yet the evidence of spectroscopy, though tremendously suggestive in the series relationships brought to light between the frequencies of the different lines of a given substance, was, after all, most disappointing, in that it remained wholly uninterpreted in terms of any mechanical model. No vibrating system was known which could produce frequencies related in the manner corresponding to the frequencies found even in the simplest of series, viz., the Balmer series of hydrogen. The discovery and study in the late nineties of corpuscular radiations of the alpha and beta type, with the changes in chemical properties accompanying them, merely

[1] Address of the president of the American Physical Society, New York, December, 1916.

served to confirm the century-old evidence of the spectroscope as to the fact of the complexity of the atom, and to educate the public into a readiness to accept it, without at first adding much information as to its nature. These studies did reveal, however, two types of bodies, the alpha and beta particles, as atomic constituents, though they said nothing at first as to their number, their arrangement, or their condition within the atom.

It was the study by Barkla of a radiation problem, namely the problem of the secondary X-radiations scattered by atoms, which furnished the first important evidence as to the number of electronic constituents within an atom. He found that the number of electrons which can act as scattering centers for X-rays is about half the atomic weight.[2] This conclusion was brilliantly confirmed by the simultaneous study in the Manchester laboratory of the scattering of the alpha rays in passing through matter,[3] and out of the converging evidence of these two types of research there emerged with considerable definiteness the Rutherford nucleus atom, consisting of a central, positively charged body of extraordinarily minute dimensions, its diameter being not over a ten thousandth of the diameter of the atom, surrounded in the outer regions of the latter by a number of negative electrons equal to about half the atomic weight. In this statement the "diameter of the nucleus" means the diameter of that portion of the atom which is found by experiment to be impenetrable to the alpha rays, while the diameter of the atom means the average distance of approach of the centers of two atoms in thermal encounters.

But it was again the study of a radiation problem which had to be called upon to furnish unquestionable information as to the exact value of this number, and at the same time to provide the most convincing evidence that we have of the general correctness of the conception of the nucleus atom.

In a research[4] which is destined to rank as one of the dozen most brilliant in conception, skilful in execution, and illuminating in results in the history of science, a young man but twenty-six years old threw open the windows through which we can now glimpse the subatomic world with a definiteness and certainty never even dreamed of before. Had the European war had no other result than the snuffing out of this young life, that alone would make it one of the most hideous and most irreparable crimes in history.

For the proof that there exist but 92 elements, from the lightest known one, hydrogen to the heaviest known one, uranium, and that these are built up one from the other by the successive addition of one and the same electrical element to the nucleus, this proof comes alone from Moseley's discovery (checked and extended as it has been by de Broglie clear up to uranium) that the square roots of the characteristic X-ray frequencies of the elements progress by almost exactly equal steps from the lightest observable one to the heaviest. Moseley proved this in a general way for both the alpha and the beta emission lines of the hardest characteristic X-ray of the elements, the so-called K rays, and also for the alpha and beta lines of the next softest series, the L series. De Broglie[5] and Hull[6] have recently shown that Moseley's law holds for the frequencies above which the different elements absorb the general radiation of tungsten. This critical frequency

[2] Barkla, *Phil. Mag.*, 21, 648, May, 1911.

[3] Rutherford, *Phil. Mag.*, 21, 669, May, 1911.

[4] Moseley, *Phil. Mag.*, 26, 1024, Dec., 1913, and 27, 703, 1914.

[5] de Broglie, *Compte Rendu*, 165, 87, 352, 1917.

[6] Hull, *Proc. Nat. Acad. of Sciences*, 2, 265, 1916.

coincides for each element, nearly, if not exactly, with the highest emission frequency characteristic of that element. De Broglie has measured accurately these critical absorption frequencies for all the heavy elements clear up to thorium, thus extending the K series from N = 60, where he found it, to N = 90—a notable advance. It is to be noted, however, that in going up from bromine, atomic number 35, to uranium, atomic number 92, the length of the step does change by a few per cent.

Now it is these radiating and absorbing properties of atoms and these alone which justify a series of atomic numbers differing from and more fundamental than the series of atomic weights. Our present series of atomic numbers is simply this Moseley series of steps based on square root frequencies. It is true that a series of atomic numbers coinciding with the series of atomic weights was suggested earlier, indeed 100 years earlier, by Prout, and by many others since then, and it is true, too, that changes in the chemical properties of radioactive substances accompanying the loss of alpha and beta particles led van den Broek,[7] just before Moseley's work appeared, to suggest that position in the periodic table might be a more fundamental property than atomic weight, but since this position is in some instances uncertain, and since the number of elements was wholly unknown, no definite numbers were or could be assigned to all the elements until Moseley's discovery was made, and the only evidence which we now have as to just how many elements there are between hydrogen and uranium, and as to just where each one belongs, is the evidence of the X-ray spectra. It is true that between helium, atomic number 2 and sodium, atomic number 11, we have no evidence other than the order of atomic weights, the progression of chemical properties and the number of known elements in this region to guide us in completing the table, but since in the region of low atomic weights the progression in the Moseley table is always in agreement with the progression in the periodic table there can be little doubt about the correct number of each element even in this region which is as yet inaccessible to X-ray measurements. Moseley's name must then be set over against one of the most epoch making of the world's great discoveries. And I wish to call attention to some important conclusions as to atomic structure which are rendered extremely probable by it.

The first is this: If we may assume that the ordinary law of inverse squares holds for the forces exerted by the atomic nucleus on negative electrons near it—and this time-honored law, so amply verified in celestial regions, has been fully verified for subatomic regions as well by the work done at the University of Manchester on the scattering of alpha rays—then the Moseley law that the square roots of the highest frequencies obtainable from different atoms are proportional to the nuclear charge[8] means, without any quantum theory, that the distances from the nucleus of each type of atom to the orbit of the inmost electron is inversely proportional to the charge on the nucleus, *i. e.*, to the atomic number. To see this it is only necessary to apply the Newtonian law connecting central force eE, orbital frequency n and radius a, namely,

$$\frac{eE_1}{a^2} = (2\pi n)^2 ma, \quad \text{or} \quad \frac{n_1^2}{n_2^2} = \frac{E_1}{E_2}\frac{a_2^3}{a_1^3} \qquad (1)$$

and then to set as the statement of Moseley's experiment

[7] Van den Broek, *Phys. Zeit.*, XIV., 32, 1913.

[8] This is the proper statement of the Moseley law, as he himself *interpreted* his experimental results. He knew and was careful to state, that there is not an *exact* linear relation between the atomic numbers and the square roots of the frequencies, but the lack of exactness of equation (2) both as

$$\sqrt{\frac{n_1}{n_2}}=\frac{E_1}{E_2}, \quad (2)$$

when there results at once from (1) and (2)

$$\frac{E_1}{E_2}=\frac{a_2}{a_1}. \quad (3)$$

It may be objected that in the setting up of these relations I have made two assumptions, the one that the electrons rotate in circular orbits, and the other that the observed highest frequencies are proportional to the highest orbital frequencies. The first assumption is justified (*a*) by the fact that the recognized and tested principles of physics give us no other known way of providing a stable system, (*b*) by the experimental facts of light (Zeeman effect) and (*c*) by the phenomena of magnetism, especially the recent ones brought to light by Einstein and de Haas,[9] and by Barnett,[10] which well-nigh demonstrate the existence of permanent and therefore non-radiating electronic orbits. The exact circular form for the orbit is a secondary matter upon which, as will appear later, it is not necessary to insist. The second assumption, that the frequencies of the corresponding emission lines in the spectrum of the various atoms are proportional to the orbital frequencies, is from *a priori* considerations probable and from certain theoretical considerations to be presented later, necessary.

A second conclusion may be drawn from Moseley's discovery that the L lines progress in frequency from element to element just as do the K lines, the frequency being in each case between 1/7 and 1/8 as great. It is that, if there is a first or inmost electronic orbit, there must also be a second one in all elements the radius of which is given by (1) to be about 8⅔ or 4 times as great as that of the first.

Guided then by the newly discovered facts of X-radiations and the unquestioned laws of force between electric charges, we get our first information as to the probable positions and conditions of some at least of the negative electrons within the atom.

Again, having found the highest natural frequency which can come from any element, viz., that from uranium, it is of extraordinary interest to inquire where, according to Moseley's law (2), the highest frequency line of the K series would fall for the lightest known element, hydrogen, whose nucleus should consist of but a single positive electron. This is obtained, as shown in (2), by dividing the observed highest frequency of any element by the square of the atomic number. The shortest wave-length given out by tungsten, atomic number 74, and the only heavy element whose X-ray constants have been accurately determined, is $.167 \times 10^{-8}$ cm. according to Hull's measurements. This gives for the shortest wave-length which could be produced by hydrogen $.167 \times 10^{-8} \times 74^2 = 91.4$ $\mu\mu$. This is as close as could be expected, in view of the uncertainties in the measurements and the further fact that Moseley's steps are not quite exact, to the head of the ultra-violet series of hydrogen lines recently discovered by Lyman and located exactly at 91.2 $\mu\mu$. There is every reason to believe, too, from the form of Balmer's series, of which this is the convergence wave-length, that this wave-length corresponds to the highest frequency of which the hydrogen atom is capable. *It is practically certain, then, that this Lyman ultra-violet series of hydrogen lines is nothing but the K X-ray series of hydrogen.* Similarly, it is equally certain that the L X-ray series of hydrogen is the ordinary Balmer series in the visible region, the head of which is at 365 $\mu\mu$. In

to straightness and as to intercept may well be attributed to secondary causes. (See below.)

[9] *Verh. d. Phys. Ges.*, XVII., p. 152, 1913.

[10] *Phys. Rev.*, 6, 239, 1915.

other words, hydrogen's ordinary radiations are its X-rays and nothing more. There is also an M series for hydrogen discovered by Paschem in the ultra-red. This in itself makes it probable that there are series for all the elements of longer wavelength than the L series, and that the complicated optical series observed with metallic arcs are parts of these longer wavelength series. As a matter of fact an M series has been found for six of the elements of high atomic weight. Thus the Moseley experiments have gone a long way toward solving the mystery of spectral lines. They reveal to us clearly and quite certainly the whole series of elements from hydrogen to uranium, all producing spectra of remarkable similarity, at least so far as the K and L radiations are concerned, but scattered regularly through the whole frequency region, from the ultra-violet, where the K lines for hydrogen are found, clear up to frequencies $(92)^2$ or 8,464 times as high. There can scarcely be a doubt that this whole field will soon be open to our exploration. How brilliantly, then, have these recent studies justified the predictions of the spectroscopists that the key to atomic structure lay in the study of spectral lines. The prophets little dreamed, however, that the study of spectral lines meant the study of X-rays. But now, through this study, a subatomic world stands revealed to us in simpler form than one could have imagined. For the atoms are now seen to be, in their inner portions at least, remarkably similar structures, with central nuclei which are exact multiples of the positive electron, surrounded in each case by electronic orbits which have certainly, so far as the inner ones are concerned, practically the same relations in all the elements, the radii of all these orbits being inversely proportional to the central charge or atomic number.

So far nothing has been said about a quantum theory or a Bohr atom. The results have followed from the known properties of assumed circular electronic orbits combined with Moseley's experimental law, as he interpreted it, and supplemented by the single additional assumption that the observed frequencies are proportional to the orbital frequencies. If they suggest, however, that the experimental facts do not necessitate the quantum theory for their complete interpretation, the consideration of the energy relations involved—these have been entirely ignored thus far—reveals at once the futility of that hope, or of that fear, according to the nature of your predilections with regard to the theory of quanta. *For the experimental facts and the law of circular electronic orbits have limited the electrons to orbits of particular radii.* But the energy principle does not permit them to be so limited without a sudden or explosive loss of energy whenever the orbit is obliged to change. Suppose, for example, that a cathode ray strikes the atom and knocks out any electron from a particular orbit. When this or some other electron returns from infinity to this orbit, it must in this act adjust its energy to the only value which is consistent with this orbit and its characteristic frequency. Hence in the act of readjustment it must radiate a definite quantity of energy. Or again, suppose that the nucleus loses a beta ray through the radioactive process. Every electronic orbit must then adjust itself to the new value demanded by Moseley's law. But this it can not do if its energy is conserved. The only way to permit it to do so is to let it radiate a definite amount of energy in the act of adjustment. This suggests that each emission of a beta ray by a radioactive substance must be accompanied by a whole series of characteristic gamma rays corresponding to each changed orbit. The emission of an alpha particle, on the other hand, would require

an absorption rather than an emission of energy, since its egress diminishes rather than increases the nuclear charge. Perhaps this is why beta rays are always accompanied by gamma rays, while alpha rays are not so accompanied. This is, however, a speculation which does not immediately concern us here. The important conclusion, for the purposes of our present subject, is that Moseley's facts and unquestionable mechanics combined with our two assumptions of circular orbits and radiation frequencies proportional in different atoms to corresponding orbital frequencies, lead inevitably to the explosive emission of energy in definite quantities accompanying orbital readjustments. And there is nothing particularly disturbing or radical about this conclusion either, for we have no basis for knowing anything about how an electron inside an atom emits its radiation. The act of orbital readjustment would be expected to send out ether waves. The only difficulty lies in the conception of stable, non-radiating orbits between which the change occurs, and whether or not we can see how such orbits can exist, the experimental evidence that they do so exist is now very strong, and it is to further evidence for their existence, since that is the main point to be established if this theory of atomic structures is to prevail, that I now wish to direct your attention.

I have already mentioned some facts of magnetism and of light which support the orbital point of view. But the strongest evidence is found in the extraordinary success of the Bohr atom, which was devised before any of these Moseley relationships, which have forced us to the essential elements of the Bohr theory,[11] had been brought to light. Bohr, however, was guided solely by the known character of the line spectra of hydrogen and helium, together with the rapidly growing conviction, now dissented from, so far as I know, by no prominent theoretical physicist, that the act of emitting electromagnetic radiation by an electronic constituent of an atom must, under some circumstances, though not necessarily under all, be an explosive process. To show what is the character of this evidence, let us consider first what are the essential elements in the Bohr theory, and, second, what have been the accomplishments of that theory. Bohr's experimental starting point is the Balmer series in hydrogen, the frequencies in which are exactly given by

$$\nu = N\left(\frac{1}{n_1^2} = \frac{1}{n_2^2}\right) \tag{4}$$

n_1 having always, for the lines in the visible region, the value 2, and n_2 taking in succession the values 3, 4, 5, etc. As previously noted, Paschen had already brought to light a series in the infra-red in which n_1 was 3 and n_2 took the successive values 4, 5, 6, etc. Lyman's discovery, subsequent to the birth of the Bohr atom, of an ultra-violet series of hydrogen lines in which $n_1 = 1$ and n_2 takes the values 2, 3, 4, etc., is not to be regarded as a success of the Bohr atom, but merely as a proof of the power of the series relationships to predict the location of new spectral lines. To obtain an atomic model which will predict these series relationships for the simplest possible case of one single electron revolving around a positive nucleus, Bohr assumed:

A, a series of non-radiating orbits governed by equation (1). This is the assumption of circular orbits governed by the laws which are known to hold inside as well as outside the atom.

B, radiation taking place only when an electron jumps from one to another of these orbits the amount radiated and its frequency being determined by $h = A_1 - A_2$,

[11] N. Bohr, *Phil. Mag.*, 26, 1 and 476 and 857, 1913. Also 29, 332, 1915, also 30, 394, 1915.

h being Planck's constant and A_1 and A_2 the energies in the two stationary states.

This assumption gives no physical picture of the way in which the radiation takes place. *It merely specifies the energy relations which must be satisfied.* The principle of conservation of energy obviously requires that the energy radiated be $A_1 - A_2$. Also this radiation must be assigned some frequency ν and Bohr placed it proportional to the energy because of the Planck evidence that ether waves originating in an atom carry away from the atom an energy which is proportional to ν.

C, the various possible circular orbits, for the case of a single electron rotating around a single positive nucleus, to be determined by $T = \frac{1}{2}\tau hn$, in which τ is a whole number, n is the orbital frequency, and T is the kinetic energy of rotation. This condition was imposed by the experimentally determined relationship of the frequencies represented by the Balmer series.

It will be seen that if circular electronic orbits exist at all, no one of these assumptions is in any way arbitrary. Each one of them is merely the statement of the existing *experimental* situation. The results derived from them must be correct if the original assumption of electronic orbits is sound. Now it is not at all surprising that *A*, *B*, and *C* predict the sequence of frequencies found in the hydrogen series. They have been made on purpose to do it, *except for the numerical values of the constants involved.* It was this sequence which determined the form given to *C*. The evidence for the soundness of the conception of non-radiating orbits is to be looked for then, first *in the success of the constants* and second *in the physical significance, if any, which attaches to assumption C.* If the constants come out right within the limits of experimental error, then the theory of non-radiating electronic orbits has been given the most critical imaginable of tests, especially if these constants are accurately determinable.

What are the facts? The constant of the Balmer series in hydrogen is known with the great precision attained in all wavelength determinations and has the value 3.290×10^{15}. From *A*, *B* and *C* it is given by the simplest algebra as

$$N = \frac{2\pi^2 e^2 E^2 m}{h^3}. \tag{5}$$

I have recently redetermined e[12] with an estimated accuracy of one part in 1,000 and obtained again the value $4{,}774 \times 10^{-10}$, which I published in 1913. I have also determined "*h*" photoelectrically[13] with an error in the case of sodium of no more than $\frac{1}{2}$ per cent., the value for sodium being 6.56×10^{-27}. The value found by Webster[14] by the method discovered by Duane and Hunt is 6.53×10^{-27}. Taking the mean of these two results, viz., $6{,}545 \times 10^{-27}$ as the most probable value, we get with the aid of Bucherer's value of e/m which is probably correct to one tenth per cent. $N = 3{,}294 \times 10^{15}$, *which agrees within a tenth per cent. with the observed value.* This agreement constitutes most extraordinary justification of the theory of non-radiating electronic orbits. It demonstrates that the behavior of the negative electron in the hydrogen atom is at least correctly described by the *equation* of a circular orbit. If this equation can be obtained from some other physical condition than that of an actual orbit it is obviously incumbent upon those who so hold to show what that condition is. Until this is done it is justifiable to suppose that the equation of an orbit means an actual orbit.

Again, the radii of the stable orbits for hydrogen are given easily from Bohr's assumptions as

12 R. A. Millikan, *Proc. Nat. Acad.*, April, 1917.

13 R. A. Millikan, *Phys. Rev.*, VII., 362, 1916.

14 *Phys. Rev.*, Dec., 1916.

$$a = \frac{\tau^2 h^2}{4\pi^2 m e^4}.$$

In other words, since τ is a whole number, the radii of these orbits bear the ratios 1, 4, 9, 16, 25. If normal hydrogen is assumed to be that in which the electron is on the inmost orbit, $2a$ the diameter of the normal hydrogen atom, comes out 1.1×10^{-8}. The best determination for the diameter of the hydrogen molecule yields 2.2×10^{-8}, in extraordinarily close agreement with the prediction from Bohr's theory. Further, the fact that normal hydrogen does not absorb at all the Balmer series lines which it emits is beautifully explained by the foregoing theory, since according to it normal hydrogen has no electrons in the orbits corresponding to the lines of the Balmer series. Again, the fact that hydrogen emits its characteristic radiations only when it is ionized favors the theory that the process of emission is a process of settling down to a normal condition through a series of possible intermediate states, and is therefore in line with the view that a change in orbit is necessary to the act of radiation. Similarly, the fact that in the stars there are 33 lines in the Balmer series, while in the laboratory we never get more than 12 is easily explicable from the Bohr theory, but no other theory has offered even a suggestion of an explanation. But while these qualitative successes of the Bohr atom are significant, it is the foregoing numerical agreements which constitute the most compelling evidence in favor of the single arbitrary assumption contained in Bohr's theory, viz., the assumption of non-radiating electronic orbits.

Another triumph of the theory is that the assumption *C*, devised to fit a purely empirical situation, viz., the observed relations between the frequencies of the Balmer series, is found to have a very simple and illuminating physical meaning, viz., the atomicity of angular momentum. Such relationships do not in general drop out of empirical formulas. When they do we usually see in them real interpretations of the formulas—not merely coincidences.

Again the success of a theory is often tested as much by its adaptability to the explanation of deviations from the behavior predicted by its most elementary form as by the exactness of the fit between calculated and observed results. The theory of electronic orbits has had remarkable successes of this sort. Thus it predicts, as can be seen from 4, 5 and 3, the relationship which we assumed, viz., that for corresponding lines (like values of n_1 and n_2 in 4) the orbital frequencies n are proportional to the observed frequencies ν and similarly it predicts the Moseley law (2). But this latter relation, which is the only one of the two which can be directly tested, was found inexact, and it should be inexact when there is more than one electron in the atom, as is the case save for H atoms and for the He atoms which have lost one negative charge, and that because of the way in which the electrons influence one another's fields. It will probably be found to break down completely for very light atoms like that of lithium. The more powerful the nucleus, however, and the closer to it the inner orbit the smaller should this effect be. Now precisely this result is observed. The Moseley law (2) holds most accurately when tested for hydrogen and the elements of highest atomic number and much less accurately when tested for hydrogen and aluminum or magnesium. Similarly the ratio between the frequencies of the α and β lines of the K series approaches closer to the theoretical value (that for hydrogen) the higher the atomic number of the element.

Again, it is now well known that the α, β, γ lines in the characteristic X-ray spectrum are not single lines as required by the simple theory. Accordingly Sommer-

feld[15] extended Bohr equations in the endeavor to account for this structure on the basis of ellipticity in some of the orbits, and Paschen[16] by measurements on the structure of the complex helium lines has obtained so extraordinary checks upon this theory that e/m comes out from his measments to within a tenth per cent. of the accepted value.

A further prediction made by the theory and discovered as soon as looked for was the relation between the lines of two succeeding series of this sort:

$$\nu_{K_\beta} - \nu_{K_\alpha} = \nu_{L_\alpha}.$$

This should hold accurately from the energy relations between the orbits whether there be one or many electrons in the atoms. I have been able to find no case of its failure, though the data upon which it may be tested is now considerable. I have also recently pointed out[17] that it is equivalent to the well-known Rydberg-Schuster law,[18] which holds quite generally among optical series. Finally, the ionizing potential of hydrogen is given by Bohr's equation as 13.54 volts while experiment yields 11.5 volts. This discrepancy in no way prejudices the theory, but rather lends it support, for the computed value is for the *hydrogen atom* while the observed value relates to the hydrogen *molecule,* which in view of the repulsions of its two negative electrons might be expected to be ionized more easily than the hydrogen atom. Similarly the computed value for helium which has lost one negative is 52.4 volts, but the helium molecule is found experimentally to be ionized at a much lower potential, viz., 20.5 volts. That Bohr computed this latter value at 27 instead of 20.5 volts is not at all serious, since he had to make very particular assumptions to get this result.

If then the test of truth in a physical theory is large success both in the prediction of new relationships and in correctly and exactly accounting for old ones, the theory of non-radiating orbits is one of the best established truths of modern physics. For the present at least it is truth, and no other theory of atomic structure need be considered until it has shown itself able to approach it in fertility. I know of no competitor which is as yet even in sight. I am well aware that the facts of organic chemistry seem to demand that the valence electrons be grouped in certain definite equilibrium positions about the periphery of the atom, and that at first sight this demand appears difficult to reconcile with the theory of electronic orbits. As yet, however, there is no necessary clash. Hydrogen and helium present no difficulties, since the former has but one valency, and the latter none. It is to these atoms alone that the unmodified Bohr theory applies, for it treats only the case of a single negative electron rotating about a positive nucleus. That the K radiations of the heavy elements are so accurately predictable from those of hydrogen indicates indeed that close to the nucleus of these elements there lie electrons to which the Bohr theory fairly accurately applies, but the radiations give us no information about the conditions or behaviors of the external electrons which have to do with the phenomena of valency and we have investigated but little the radiating properties of the atoms which possess but few electrons. A further study of the behavior with respect to X-rays of the elements from lithium, atomic number 3, to sodium, atomic number 11, may be expected to throw new light on this problem.

It has been objected too that the Bohr theory is not a radiation theory because it gives us no picture of the mechanism of the

15 *Annalen der Physik.*, 51, 1, 1916.

16 *Annalen der Physik.*, Oct., 1916.

17 *Phys. Rev.*, May, 1917, presented before American Physical Society, December 1, 1916.

18 Baly, "Spectroscopy," p. 488.

production of the frequency ν. This is true, and therein lies its strength, just as the strength of the first and second laws of thermodynamics lies in the fact that they are true irrespective of a mechanism. The Bohr theory is a theory of atomic structure; it is not a theory of radiation, for it merely states what energy relations must exist when radiation, whatever its mechanism, takes place. As a theory of atomic structure, however, it is thus far a tremendous success. The radiation problem is still the most illusive and the most fascinating problem of modern physics. I hope to discuss it at a later time.

R. A. Millikan

Ryerson Laboratory,
University of Chicago

GEORGE CHRISTIAN HOFFMANN

George Christian Hoffmann, formerly assistant director, chemist, and mineralogist of the Geological Survey of Canada, died in Ottawa, March 8, 1917. He was born June 7, 1837, in London, England, and studied at the Royal School of Mines under Sir Henry de la Bèche, under Hoffman, Percy, Smyth, Stokes, Ramsay, Huxley and Willis. He spent several years as chemist in research laboratories of England, and later 1861, wrought in Natal, South Africa, in the Mauritius, later again in Australia. In 1872 he joined the technical staff of the Geological Survey of Canada, Montreal, under Dr. Alfred R. C. Selwyn. Dr. Hoffmann was a fellow of the Institute of Chemistry of Great Britain, a fellow of the Royal Society of Canada and of many other distinguished bodies. He is the author of many numerous reports published by the Geological Survey of Canada and the Department of Mines. While in Australia he devoted considerable time in the phyto-chemical laboratory attached to the Melbourne Botanic Garden in Victoria; inquiries into the tanning properties of the barks of native trees; investigation into the amount of potash in various indigenous trees, besides experiments in reference to various acids, tar and other products. Besides the above enquiry into the suitability for paper-making of various fibrous substances were carried on by Dr. Hoffmann. The essential oils of certain trees, dyeing properties and coloring matter of others and researches on tea, opium and various economic products were carried out in conjunction with Baron Ferdinand Mueller, the distinguished Australian botanist. His bibliography contains valuable reports and papers of analyses and determinations of Canadian ores, minerals and economic products characterizing the rock formations of Canada and elsewhere, including rare and new species.

H. M. Ami

British Embassy,
Washington, D. C.

SCIENTIFIC EVENTS

LECTURES ON SANITARY SCIENCE AT RUTGERS COLLEGE

In connection with the recently established course in sanitary science, Rutgers College has inaugurated a series of public lectures. The list follows:

November 27. Professor Jacques Loeb, of the department of experimental biology of the Rockefeller Institute, New York City, "Regeneration."

February 5. Dr. J. G. Needham, professor of entomology, Cornell University, "Action."

February 28. Dr. G. M. Potter, of the Bureau of Animal Industry, Washington, D. C., "Abortion Diseases of Cattle."

March 7. Professor A. E. Taylor, Ph.D., University of Pennsylvania, "Agricultural Production in Germany under Blockade."

March 8. Mr. Allen Hazen, C.E., New York City, "Purification of Water Supplies."

March 14. Dr. K. F. Kellerman, associate chief of the Bureau of Plant Industry, Washington, D. C., "Relation of Algæ to Public Water Supplies."

March 19. Dr. J. F. Anderson, director of Squibb's Laboratory, New Brunswick, N. J., "Anaphylaxis."

March 21. Dr. Theobald Smith, director of the department of animal pathology of the Rockefeller Institute, Princeton, N. J., "Research in Animal Diseases with Reference to Agriculture and the Industries."

March 22. Dr. Theobald Smith, director of the department of animal pathology of the Rockefeller

Institute, Princeton, N. J., "Research in Animal Diseases in their relation to Public Health."

April 3. Dr. C. L. Alsberg, chief of the Bureau of Chemistry, United States Department of Agriculture, Washington, D. C., "The Administrative Control of our Food and Drug Laws."

April 11. Dr. J. F. Anderson, director of Squibb's Laboratory, New Brunswick, N. J., "Public Health Administration."

April 17. Dr. W. T. Sedgwick, director of the department of biology and public health, Massachusetts Institute of Technology, Boston, Mass., "Preparation for Public Health Work."

April 18. Dr. R. B. Fitz-Randolph, assistant director of the state hygienic laboratory at Trenton, N. J., "Public Health Conditions as they are in New Jersey."

April 19. Dr. R. B. Fitz-Randolph, assistant director of the state hygienic laboratory at Trenton, N. J., "Public Health Conditions as they should be in New Jersey."

April 20. Dr. V. A. Moore, dean of the New Jersey State Veterinary College, Cornell University, "Tuberculosis in Cattle with Special Reference to Infected Milk."

April 26. Dr. A. C. Abbott, director of the laboratory of hygiene of the University of Pennsylvania, Philadelphia, Pa., "Control of Transmissible Diseases."

May 3. Dr. E. G. Conklin, professor of biology at Princeton University, "Heredity and Democracy."

May 7. Dr. P. H. Mitchell, professor of physiology at Brown University, and summer director of the United States Fisheries Laboratory at Woods Hole, Mass., "Live Problems in Nutrition Research."

May 16. Mr. G. Fuller, engineer and sanitary expert, New York City, "What shall be the Limitation in the Pollution of Raw Waters so that they may be safely purified by modern Water Treatment Plants."

May 17. Mr. G. Fuller, "The Present Status of Sewage Disposal Methods."

SCIENTIFIC RESEARCH AND THE ELECTRICAL WORLD

A department of Scientific and Industrial Research will be henceforward one of the features of *The Electrical World*. The department is to be conducted by Professor Vladimir Karapetoff, of Cornell University, and has for its object the "Interchange of Ideas, Investigations Contemplated, Research Facilities Available, and Suggestions for Cooperative Work." The scope of the research section is described in the issue of March 17, as follows:

This section is started without preconceived ideas, but with a sincere desire to serve the interests of electrical research and of investigators. In it will be embraced:

1. Interchange of ideas among investigators in the electrical industry and in pure science on some important problem to be solved.

2. Questions regarding some topic in research to be undertaken.

3. Suggestions and answers to questions from those who are in a position to advise.

4. Brief reports on some electrical research in progress or results obtained.

5. Information regarding facilities available for electrical research in private, federal, technical-school or public service company laboratories.

6. Discussions and tabulations of some important research problems in the various branches of electrical industry and science with the idea of concentrating the attention of the investigators on those problems.

7. Suggestions and arrangements for cooperative research where it is superior to uncorrelated individual efforts.

Short contributions bespeaking the support of electrical research, or that tend to enhance its dignity and show its importance in the cultural standing, prosperity and safety of the country, will also be welcome.

A few experienced, skilled and competent investigators can not of themselves accomplish much, any more than a few generals without an army. A large number of young electrical engineers and physicists must be encouraged and interested in research, because from their ranks future great investigators will arise. Many will become useful assistants in research, still others will at least realize the importance of research and will encourage it when they reach positions of authority. Above all, a circle of sympathetic readers must be created who will follow research, delight in new achievements, and lend moral and material support to faithful workers. Otherwise the section will be like a major league team playing a spirited game before an empty grandstand.

This, then, is a request for cooperation from those who are interested in research, be it practical or theoretical. Let the profession know what you are doing and how you are doing it. Let us all rejoice in your triumphs, and let us lighten your difficulties or disappointments if possible. If the

task is too large for you, others may be willing to cooperate and help achieve results.

Following are some suggestions as to how you can do your share in this great and important work of inventorying and stimulating electrical research:

1. Indicate the most important problems in the branch of electrical engineering in which you specialize. These may be problems on which you are working, or suggestions for investigations by others.

2. Give a brief account or at least titles of investigations that you are conducting, or of the research recently done under your supervision. This information will be published for the purpose of bringing together those working on some problem now, and also those who may take it up later.

3. Describe briefly the experimental facilities at your disposal and the kinds of problems for which they are particularly suitable; also other facilities that you may possess, such as a large amount of data on file, a collection of pamphlets on some topic, natural advantages of location, etc.

4. Ask questions, if you have any, or express a desire to get in touch with other investigators on some topic.

5. Give your general views on electrical research and on how to encourage it and make it more productive.

A CENSUS OF CHEMISTS

Dr. van H. Manning, director of the Bureau of Mines, and Professor Julius Stieglitz, president of the American Chemical Society, have addressed a letter to American chemists asking them to fill in a blank giving information concerning their chemical experience and qualifications. The letter reads:

By request of the Council of National Defense, the Bureau of Mines, in cooperation with the American Chemical Society, will procure a roster of chemists of the United States. Data covering the qualifications, experience and skill of each chemist are desired to determine the line of duty in which he could best serve the country in time of need.

European experience has shown that nothing is more important in time of war or other national emergency than a knowledge of the qualifications and experience of the country's expert technical men. Men whose knowledge was invaluable to the production of munitions ordnance and supplies were killed in the trenches during the first months of the European war. This was due to lack of early information regarding individuals and has now been remedied in every European country. It is therefore important, especially at present, that this information be available in the United States.

You are accordingly requested, as a patriotic duty, not only to fill out the card which you will receive herewith, but to see that every chemist within your acquaintance receives one and does likewise. Additional cards will be furnished upon request. You will please check only those subjects in which you are expert, especially where you have had actual manufacturing experience. Please return the card promptly, using the enclosed franked envelope. The information received will be carefully classified, carded and indexed. Your prompt response to this matter will be very much appreciated.

SCIENTIFIC NOTES AND NEWS

At the meeting of the National Academy of Sciences, which will be held in Washington on April 16, 17 and 18, the Hale lectures will be given by Professor Edwin G. Conklin, of Princeton University, on "Methods and Causes of Organic Evolution."

The American Philosophical Society, which will hold its general meeting at Philadelphia on April 12, 13 and 14, has arranged a symposium on aeronautics. Papers will be presented by Professor A. G. Webster, of Clark University; Brigadier General George O. Squier; Dr. W. F. Durand, chairman of the National Advisory Committee for Aeronautics, and Dr. Charles F. Marvin, chief of the U. S. Weather Bureau.

The twenty-fifth anniversary of the New York Section of the American Chemical Society was celebrated with a dinner and smoker at the Chemists' Club, on March 9, 1917. The opening remarks of Chairman Matthews were followed by addresses by Provost Edgar F. Smith, of the University of Pennsylvania, on "Robert Hare"; Dr. Wm. H. Nichols on "The Early History of the Society," and Dr. E. G. Love on "The First Years of the New York Section." Dr. Charles A. Doremus presented to the Section a large steel engraving of Professor J. W. Draper, first president of the American Chemical Society.

The David Livingstone gold medal of the American Geographical Society has been conferred on Mr. Theodore Roosevelt in recogni-

tion of his scientific achievement in the field of geography of the southern hemisphere. Mr. Roosevelt addressed the meeting after the presentation.

ON the evening of March 24, at a banquet given for Professor Anton Julius Carlson, fifty of his former pupils who have taken higher degrees under him presented him with a Sigma Xi key jewelled with diamonds and a memorial booklet containing the autographs of all the participants. Professor Carlson has just completed his tenth year as director of mechanical physiology at the University of Chicago.

SIR J. J. THOMSON, Cavendish professor of physics at the University of Cambridge and president of the Royal Society, Sir David Prain, director of Kew Botanical Gardens, and Sir George Beilby, head of the Royal Technical College of Glasgow, have been elected trustees of the Carnegie Trust for Scottish Universities.

WE learn from *Nature* that the following have been elected ordinary fellows of the Royal Society of Edinburgh: G. B. Burnside, Dr. B. Cunningham, T. C. Day, R. W. Dron, Professor A. Gibson, J. Harrison, Professor J. C. Irvine, A. King, Sir Donald Macalister, Reverend H. C. Macpherson, Lieutenant L. W. G. Malcolm, A. E. Maylard, G. F. Merson, F. Phillips, Dr. H. H. Scott, Sir G. A. Smith, Dr. J. Tait, Dr. W. W. Taylor, J. McLean Thompson, W. Thorneycroft and Professor D. F. Tovey.

SIR W. E. GARSTIN and Sir G. K. Scott-Moncrieff have been elected honorary members of the British Institution of Civil Engineers.

PROFESSOR C. VERNON BOYS has been elected president of the London Physical Society.

DR. CHARLES H. HERTY, editor of the *Journal of Industrial and Engineering Chemistry*, has been elected chairman of the New York Section of the American Chemical Society.

DR. KENNETH TAYLOR, formerly of St. Paul, has been appointed director of the Robert Walton Goelet Research Laboratories which are housed in the Doyen Hospital, Paris.

ACCORDING to *Nature* a letter lately received from Dr. Ragnar Karsten, leader of the Swedish expedition in Ecuador, is dated El Tena, East Ecuador, October 10, 1916, and states that the expedition was then half-way along the difficult road from Quito to Napo, at which latter place and at Curaray ethnographical studies and collections would be made.

MR. HOWARD F. WEISS has resigned as director of the Forest Products Laboratory of the United States Forest Service to become associated with the C. F. Burgess Laboratories, Madison, Wis.

GEORGE HERBERT PALMER, Alford professor of philosophy, emeritus, in Harvard University, delivered the annual charter day address in the Greek theater of the University of California on March 23, the forty-ninth anniversary of the chartering of the University of California by the state.

THE last of the Harvey Society lectures will be given at the New York Academy of Medicine, New York, on April 7, when Professor William H. Howell, of the Johns Hopkins University, will speak on "The Coagulation of the Blood."

PROFESSOR C. K. LEITH, of the University of Wisconsin, has recently completed a six-weeks' course of lectures on metamorphic geology at the University of Chicago.

AT the meeting of the University of Pennsylvania chapter of Sigma Xi, on March 14, Dr. William Curtis Farabee gave an illustrated address on "Some Myth Makers of the Amazon," based on his recent travels in South America, and Dr. George B. Gordon, director of the University Museum, spoke on "The Museum's Work in Exploration."

DR. DAVID D. WHITNEY, professor of zoology in the University of Nebraska, gave an illustrated lecture on "Sex Determination" before the Science Club of Kansas State Agricultural College on March 20.

DR. FELICE FERRERO, American representative of the Italian press, will give a series of three lectures on the History of Science at Harris Hall, Northwestern University. The lectures will be as follows:

Thursday, March 29. "The Period of Philosophical Speculation. Theories of Evolution and Arithmetic."

Saturday, March 31. "The Shift to Experimental Methods. Aristotle, the Naturalist, the Astronomer and the Physicist."

Monday, April 2. "The Great Lights of Ancient Science: Archimedes and Hipparchus."

The third Guthrie lecture of the Physical Society, London, was given on March 23, by Professor P. Langevin, on "Molecular Orientation."

Jonathan Risser, professor of zoology at Washburn College and previously assistant professor at Beloit College, died on March 23, aged forty-eight years.

David H. Browne, a metallurgical engineer living at Montclair, N. J., known for his work in copper smelting, died on March 30, at the age of fifty-three years.

Dr. E. P. Ramsay, curator for many years of the Australian Museum, Sydney, author of works on ornithology, has died at the age of seventy-four years.

The death is announced, in his ninety-second year, of James Forrest, honorary secretary, and for many years the secretary, of the Institution of Civil Engineers.

General J. A. L. Bassot, the distinguished French geodesist, has died at the age of seventy-six years.

Among New York State civil service examinations to be held on May 5, are examinations for the position of assistant bacteriologist in the State Department of Health, with salaries of $900 to $1,800.

The annual meetings of the American Association of Pathologists and Bacteriologists and of the American Association of Immunologists is being held in New York City on April 6 and 7, under the presidency of Dr. Richard Weil. The sessions will be held at the New York Academy of Medicine and at the Rockefeller Institute.

The Peabody Museum of Yale University, which for forty years has housed the Marsh collection of fossils, the Gibbs mineralogical collection, for which citizens of the city and Yale paid $20,000 almost a hundred years ago that it might not go to the city of Hartford, and other collections of more recent date, closed its doors to the public last week. With the razing of this old natural history museum will pass out of existence the building that has been the college home of many distinguished members of the Yale faculty, including James Dwight Dana, Othniel Charles Marsh, Addison E. Verrill, Sidney I. Smith and George Jarvis Brush. Visitors will have no opportunity to see the university's collections in natural history until the new museum on the Sage-Pearson plot is finished.

UNIVERSITY AND EDUCATIONAL NEWS

At the Charter Day exercises of the University of California on March 23, President Benj. Ide Wheeler announced that the gifts of the previous twelve months amounted to approximately half a million dollars, among the principal items being the $70,000 given by Professor and Mrs. George Holmen Howison to endow a fellowship in philosophy, scholarships in English, etc.; $200,000 provided by the late Mrs. Elizabeth Josselyn Boalt to endow instruction in the school of jurisprudence; $43,-493 given by various friends of the university to furnish and equip the new University Hospital in San Francisco, a 215-bed teaching hospital, itself built through gifts of $586,000 from a number of different benefactors, and $80,000 expended during the year by the gift of Miss Ellen B. Scripps, for a new thousand-foot concrete pier, a new library and museum building, etc., for the Scripps Institution for Biological Research at La Jolla.

Mr. Charles W. Bingham (Yale, '68), of Cleveland, Ohio, has given $10,000 to Yale University for the endowment of scholarships to be awarded to graduates of the high schools of Cleveland and its vicinity entering the college or the scientific school.

All Souls College, Oxford, has given the university fifteen hundred pounds in aid of the general fund and the like sum for the Bodleian Library.

Dr. Charles A. Mann, of the University of Wisconsin, has been appointed associate professor of chemical engineering at Iowa State College, to succeed Professor George A. Gabriel, who has resigned to undertake industrial work.

At Yale University Samuel James Record, at present an assistant professor in the Forestry School, has been elected professor of forest products, and Assistant Professor Ralph Chipman Hawley has been promoted to a full professorship of forestry.

Howard Lilienthal, M.D., (Harvard, '87), has been appointed professor of clinical surgery in the Cornell University Medical School.

Mr. E. D. Merrill, botanist in the Bureau of Science, Manila, and for the last four years associate professor of botany in the University of the Philippines and head of the department, has been promoted to the full professorship. His services will be divided between the university and the Bureau of Science as in the past.

The resignation of Dr. E. A. Letts from the chair of chemistry in the Queen's University, Belfast, is announced.

DISCUSSION AND CORRESPONDENCE

EPICENE PROFILES IN DESERT LANDS

In the genetic analysis of the land forms characteristic of arid regions there seems to be an inexplicable proneness to derive all relief effects not through means of the mastering erosive powers peculiarly dependent upon aridity but through the operation of the same geologic processes which produce the landscape features under conditions of normal humid climate. This far too general tendency to regard all geographic agencies as differing merely in degree and not in kind inevitably leads to erroneous conclusions concerning the origin of many relief details. Although in the instance of desert lands there are not only more but different erosional agencies to be taken into account there is actually less complexity involved than in moist lands. On the other hand while there is still the simultaneous working of several distinct processes a little-known one becomes dominant and so thoroughly ascendant as to all but completely obscure the operations of the others. To this aspect of the desert problems little attention has been heretofore devoted.

Although this exceptional simplicity of landscape derivation obtains in typically desert tracts it appears to be not nearly so prevalent either on the borders of the desert or in the penumbral semi-arid belts. In the last mentioned situation there is a notable mingling of relief effects produced by the action of several distinct erosional processes. Here recorded observation chances to be most extensive and generalization most rampant. Here, too, because of the fact that the examination of the features is attended by strong bias of moist climate experience misinterpretation of true desert characters is rife.

By inference, at least, use of the title "Epicene Profiles" applied to arid tracts, presupposes the recognition of other relief effects. The orogenic profile which has been so long inseparably associated with desert topography is at once relegated to the back-ground. By its elimination a diametrically opposed proposition is substituted for that most brilliant of geological concepts—the fault-block hypothesis of basin range structure whereby the mountain prisms are tilting and floating as do ice-cakes in a river at time of spring break-up.

The early impression that desert ranges, as those of the Great Basin for instance, are buried mountains still strongly persists. But there are many phenomena in such regions that water-action does not begin to explain. The rock-floor which many intermont basins display is one of them. The smooth plains surface of enisled landscapes at once excites greatest interest. To find such tracts areas of profound degradation instead of extensive aggradation, as one is led to expect after accepting the water-action hypothesis, is truly surprising. Whether desert tracts of this description owe their facial expression mainly to pre-arid corrasion by streams all traces of which have long since vanished, whether the sloping interment plains are the result of sheet-flood erosion, or, as is still more lately proposed, the rock-floor of desert piedmonts is due to

former stream-planation and burial by mountain wash which by stream-action at a later stage is again removed the fact remains that the finest and most extensive rock-floors are found in situations where no water-action could possibly have occurred. For all these cases other suggestions of genesis is, of course, necessary.

The local exhuming of the rock-floors of arid piedmonts by the removal of its wash mantle does not really demand any elaborate inductive reasoning in order to reach an adequate explanation of the phenomenon. It is one of the commonest features of the desert. The effect is sometimes repeated over the same district several times in a year. It has been known to take place over night—by wind action. In the semi-arid belt, or on the margin of lofty mountains, as the Sierra Nevada in California for example, the local removal of the soil layer might be at first glance ascribed to stream-action; but broader observation extending to typical desert regions, where only low hills prevail, demonstrates at once that the stream-planing hypothesis must be entirely abandoned. The extension of moist-climate principles of erosion to arid lands is done with constantly growing difficulty.

In support of the idea of the eolic derivation of many rock-floored piedmont plains there are ample published observations. The late W J McGee's descriptions of the phenomenon as displayed in Sonoran deserts are pertinent. A single experience of my own when encamped on the Jornada del Muerto at the northern end of the Mexican tableland is by no means an isolated instance. There at the foot of a mountain apparently "buried up to its shoulders in its own débris" a strong gale which suddenly arose completely swept away in a half hour's time the supposedly deep soil and laid bare the smoothest and hardest of rock-floors worn out on the upturned edges of most resistant strata. Since the situation was at the mouth of a canyon and upon the back of what appeared to be a broad alluvial fan, a day's later visit might have ascribed the phenomenon to stream work.

Charles Keyes

NOTES CONCERNING THE FOOD SUPPLY OF SOME WATER BUGS

In the literature dealing with aquatic Hemiptera, we are informed that without exception they are predatory: those which dwell upon the surface capturing such flies and other terrestrial insects as may chance to fall into the water, and those that pass their lives beneath the surface preying upon aquatic insects and similar organisms.

In the light of recent observations along this line, the above information seems inadequate. Corixids for instance are largely herbivorous. The bulk of the food of our common water-strider, *Gerris marginatus*, consists at certain times of the year almost exclusively of the Jassids and related forms that feed on *Juncus* and other plants bordering on and growing in the shallow waters.

Our common species of *Rheumatobates*, while it does not disdain to feed upon small insects that fall into the water, obtains its main supply from the little crustacean forms such as Ostracods and Daphnians, which swarm the quiet pools. These it captures as they rest at the surface, scooping them out and holding them aloft upon the upturned tip of the beak, while the body of the little victim is being depleted of its nutritive material. A species of the genus *Microvelia* common in Kansas has access to the same source for its food supply and similar habits of consuming it. *Mesovelia mulsanti*, our little green Gerrid, has been observed exploring the sides of stems of *Juncus* and *Typha* that lay just beneath the surface for Ostracods, which they occasionally obtained, while the well-known marsh treader, *Hydrometra martini*, stalks about over the floating vegetation in search of whatever small beings chance to come to the surface film. Its victims have been observed to consist of mosquito wigglers, mosquito pupæ, emerging midges, nymphal corixids, and Ostracods, as well as small terrestrial insects floundering on the water.

Among the bugs that live in the water, none are more common than the back-swimmers, or Notonectids, and the water boatmen, or

Corixids. The former feed in their first three stages largely upon the small crustacea—Ostracods, cyclops and Daphnians, etc.,[1] adding to this diet such other forms as they are able to master, including corixids, mosquito larvæ and their own weaker brothers, while the source of the food supply of the boatmen[2] is found in the brown, sedimentary material on the bottom of the pool. This they scoop up with the flat rakes of their fore-legs. These rakes are the somewhat spoonshaped terminal segments or *palæ,* which are most admirably equipped for their work. An examination of the contents of the digestive tract reveals much of disorganized unicellular plant matter, diatoms, oscillatoria, euglenæ, chlamodomonas, and occasionally the shell of an arcella, or the remains of other lowly animal forms.

Thus, it may be noted that the Corixids can be looked upon as members of the producing class in the waters where they are found. Gathering their food from the slimy ooze at the bottom of the pool, they in turn make forage for the many predatory animals that lurk in the shadowy places or dart in pursuit of their prey. We have witnessed their capture by Notonectids, Naucorids and nymphal Belostomas, by the larvæ of Dyticids and Gyrinids, and are forced to believe that they take their place with the Entomostraca in furnishing food supply. Their alertness and agility, however, permit them to maintain themselves even in waters swarming with carnivorous forms, while in proper waters, with an absence of a dominating predatory population, they thrive in astonishing numbers.

More might be said concerning the rôle played by the aquatic Hemiptera in the society of water forms, but this will suffice to indicate that they have a part not heretofore recorded—an intimate relation to certain of the Entomostraca, and even to the unicellular life of our ponds and pools. H. B. HUNGERFORD

CORNELL UNIVERSITY

1 We have reared *N. undulata* to end of fourth instar in a small Petri dish, its only food being ostracods supplied to it daily by means of a pipette.

2 We have carried a species of boatmen through its entire cycle as many as twelve individuals in a single Petri dish upon such fare.

THE DOCTRINE OF EVOLUTION AND THE CHURCH

TO THE EDITOR OF SCIENCE: In the minds of those who are beginning to be classed among the older men, there still lingers the memory of the time when the pulpit hurled its denouncements against those men of science who had the temerity to accept the doctrines of evolution as advanced by Darwin and Huxley.

An interesting instance of the entire change of opinion that has come over the clergy is shown by an experience that occurred at the exercises connected with the celebration of the one hundredth anniversary of the consecration of St. John's Church in Washington City on January 14, 1917.

A former rector of St. John's, the Rev. Dr. George William Douglas, now a canon of the Cathedral of St. John the Divine in New York City, in a sermon in which he reviewed the history of the church, spoke of a century as being a very short time in comparison with the time during which man had inhabited our earth, quoting Henry Fairfield Osborn's recent work on "Men of the Old Stone Age" as his authority, for the number of years.

It is a far cry to the Oxford meeting of the British Association in 1860 when the learned Bishop Wilberforce attempted so unsuccessfully to controvert Huxley, the youthful advocate of science, then well nigh unknown outside the narrow circle of scientific workers.

On Huxley's tomb are these words:

> And if there be no meeting past the grave,
> If all is darkness, silence, yet 'tis rest.
> Be not afraid, ye waiting hearts that weep,
> For God "still giveth his beloved sleep,"
> And if an endless sleep he will—so well.

Sir Michael Foster once said:

> Future visitors to the burial place [of Huxley] on the northern heights of London, seeing on his tomb the above lines, will recognize that the agnostic man had much in common with the man of faith.

It is interesting to note the fact that Osborn was a pupil of Huxley's and by chance was in

the congregation when Dr. Douglas preached his sermon.

Marcus Benjamin

THE MANUFACTURE OF APPARATUS AND CHEMICALS

To the Editor of Science: It has often occurred to me that it would be beneficial to science if some of the large universities of this country would cooperate to build a factory where chemicals and apparatus would be manufactured and sold to the various scientific institutions at a correct margin of profit. Perhaps the Rockefeller or Carnegie Foundation could be interested in such a project. The majority of fellow investigators and university professors would welcome such an arrangement, for it would make material accessible which is difficult to obtain otherwise and might be an important source of instruction to industrial chemists and physicists.

Louis Baumann

The State University of Iowa

LORD LISTER ON THE VALUE OF VIVISECTION

To the Editor of Science: In reference to the letter from Lord Lister to myself published in Science of March 30, 1917, I beg leave to make this explanation. Recently the original copy of this letter has been found. It is dated 12 Park Crescent, Portland Place, London, West, 4th of April, 1898, and addressed to myself. Just after its receipt I handed it to a friend to use in connection with the hearing before the United States Senate on the Gallinger Bill relating to animal experimentation in the District of Columbia. My friend presented it at the hearing and it is published in the pamphlet relating to that hearing.

When Sir Rickman Godlee sent me a copy of the "rough draft" of this letter not long ago, saying if it had been received he would like to publish it in his "Life of Lord Lister," I went with great care over all of my letters and could not find the original. As it was almost a score of years since it had been received I had quite forgotten it and came to the conclusion that either it had gone astray in the mails or had never been sent. It has been returned to me and I have placed it in the Library of the College of Physicians of Philadelphia.

W. W. Keen

Philadelphia, Pa.,
March 31, 1917

QUOTATIONS

THE AMERICAN ASSOCIATION AND WORK IN AGRICULTURE

The annual meeting of the American Association for the Advancement of Science is one of the great scientific events of the year. It is a vast clearinghouse for ideas and results in science, and for the testing and molding of views. It presents the largest forum in this country for healthy, tempered but searching criticism in science, without which science becomes self-complacent, lax and unexacting in its requirements.

Beyond this, such a meeting of men associated with the various branches of science has a remarkably broadening influence. One gets new insight, suggestion and inspiration from such a contact of minds, such a presentation of evidence, such a weighing and testing of results and of views. The individual finds anew that his branch of science or his specialty has relations beyond the narrow limits in which he has been considering it, and that there is not only an interest in following this broader relation, but a danger unless he does that he may specialize too closely in his thinking and view his subject out of focus.

Hence it seems worth while for the man of science to foregather from time to time with his colleagues in the annual convocation, worth the time and worth the money outlay. This is not so much to listen to papers which might be read or to present a report which might be published, but to keep his mind from narrowing, to maintain a contact with science which is well nigh impossible otherwise, and an association which contributes so much to the zeal and the satisfaction of a scientific career. It brings him definitely into membership in that great fraternity of workers in the broad field of science—some for its own sake, some for its relations to human welfare, all having the common purpose to advance knowledge and understanding. It was the belief in such advantages that led thousands of men and women to jour-

ney long distances, many from the south and the west, to attend the New York meeting.

The relation to agriculture of considerable parts of the programs of various sections and affiliated societies seems increasingly greater with each succeeding meeting. Perhaps it is because our interest is broadening. Perhaps it is because the investigation in agriculture is leading more and more deeply into the realm of the sciences. And undoubtedly it is because interest in these problems is becoming more widespread, for the problems of agriculture are now attracting the attention of very many men and women identified with nonagricultural institutions. The biological chemists, the various botanical organizations, the entomologists, the zoologists, the geneticists, the ecologists, all had papers of immediate import to agricultural investigation. Indeed, there were so many of these contributions and discussions that the difficulty was to hear more than a small part and to make a selection.—*Experiment Station Record.*

SCIENTIFIC BOOKS

Plant Succession. An Analysis of the Development of Vegetation. By FREDERIC E. CLEMENTS, Carnegie Institution of Washington, Publication Number 242, Washington, D. C., 1916. Pp. xiii + 512, 61 half tone plates of two to three figures each, and 51 figures in the text.

For nearly a quarter of a century the author of this large and attractive volume has been investigating numerous problems in the field of phyto-ecology and related subjects as he has found them in the great out-of-door laboratory of western United States. This area is particularly stimulating for such work since so many of the natural life phenomena have been preserved to the present in nearly their original conditions. During these years the author has been favored with unusual facilities for the conduction of his investigations. Because of these facts, as well as because of the well-known leadership which American ecologists enjoy, this latest work from Clements will attract the attention of botanists and biologists in general throughout the world.

The reader must understand that this work is not in any sense a treatise on general plant ecology. It represents a careful examination of the facts and principles of plant succession, an analysis of the development of vegetation in the past as well as the present, together with a digest of the methods for investigating successional phenomena.

The subject-matter of the monograph is arranged in fifteen subdivisions or chapters. In Chapter I. the author rewrites his rather familiar views as to the fundamental nature and causes of succession. He points out that "the developmental study of vegetation rests upon the assumption that the unit or climax formation is an organic entity." As a living entity this unit arises, develops, matures and eventually disappears. All such entities or formations develop as a result of succession which may occur again and again in the history of each climax unit. The most striking external feature of succession lies "in the movement of populations, the waves of invasion, which rise and fall through the habitat from initiation to climax."

An excellent historical summary beginning with King (1685) and including the work of twentieth century ecologists is included in Chapter II. This is a valuable summary of the concepts that have helped in shaping modern ideas with regard to plant succession.

Then follows a long chapter on the causes of succession. "Initial causes" are discussed under the captions: Topographic Causes, Erosion, Deposit, Elevation and Subsidence, Edaphic Causes, Climatic Causes, Biotic Causes, while "ecesic causes" are enumerated as Aggregation, Migration, Ecesis, Competition and Invasion. This chapter is followed by a study of stabilization and the development of the final or climax community.

The structure and units of vegetation are treated at length and the views of various ecologists upon these subjects summarized. One of the most interesting, as perhaps most valuable, parts of the book is the attempt of the author to focus attention more sharply than has ever been done before upon the fact that plant communities may and should be

classified by means of seral units as well as by climax units. Both methods have been used by various investigators rather indiscriminately, or at least no particular model (if there be such) has been followed consistently. Clements rightly emphasizes the desirability of working out and adopting a set of terms to cover these two concepts of vegetation and he goes so far as to propose terms by means of which the various climax and seral features of the plant formation may be described. The reviewer is aware of the advantages and disadvantages of the various systems which have been proposed in the past and we must confess that this latest proposal is perhaps still far from the ideal, and yet it represents an advance, it marks progress. At least it serves to focus the attention upon the dynamic phases of vegetation as apart from the static. The author may be criticized for the introduction of new terms in this connection, but new concepts or relations may be expressed only by appropriate words. Scientific men should not be confounded by the introduction of an occasional new term.

The *climax* units which Clements proposes are: *associations,* climax communities which associated regionally constitute the formation; *consociations,* the units of the association, characterized by a single dominant species; *societies,* communities within an association or consociation controlled by one or more subdominant species; and *clans* or aggregations of secondary species within either of the above subdivisions. The clan is quite local and often not sharply delimited from the society.

Seral units are analogous to climax units or communities throughout the course of succession. These units are proposed in order to point out sharply the distinctions between the developmental or dynamic and climax or static phases of vegetation. The *associes* is the developmental equivalent of the association, differing from the latter only in its transient nature. The *consocies* corresponds to the consociation in the same manner that associes corresponds to association. "The consocies is a seral community marked by the striking or complete dominance of one species, belonging, of course, to the life-form typical of that stage of development." The *socies* is likewise the developmental equivalent of the society. The *colony* is an *initial* community of two or more species. Colonies resemble clans in their limited size and absence of clearly defined relation to the habitat. From their appearance in bare areas colonies are nearly always sharply delimited. The invasion of weeds frequently follows the colony type of grouping. The *family* is a group of individuals belonging to one species. Because of this nature families are quite rare in general, but they are common in bare areas and in the initial stages of a succession. This attempt to work out a classification of vegetation types founded upon the developmental basis should appeal to all broad-minded students of plant ecology.

Another valuable portion of Clements's book is the part devoted to the climax formations of North America as summarized from the available literature.

Successional studies in Eurasia are also abstracted.

An extended portion of the monograph is devoted to a discussion of "past climates and climaxes" or to the succession of vegetation in remote times as revealed in the geological record. "The operation of succession was essentially the same during the geological past that it is to-day: from the nature of their vegetation forms, the record deals largely with the ultimate stages of such successions. It is evident that geological succession is but a larger expression of the same phenomenon, dealing with infinitely greater periods of time, and produced by physical changes of such intensity as to give each geological period its peculiar stamp. If, however, the geological record were sufficiently complete, we should find unquestionably that these great successions merely represent the stable termini of many series of smaller changes, such as are found everywhere in recent or existing vegetation. . . . In short, the development and structure of past vegetation can be understood only in consequence of the investigation of existing vegetation."

The investigations of Douglas on "Weather Cycles in the Growth of Big Trees" and "A Method of Estimating Rainfall by the Growth of Trees," of Huntington on the climatic factor, and of Humphreys on the relation of volcanic dust to climatic changes, etc., appear to have been the chief inspiration and sources for this particular portion of the monograph.

This is a very new field for the modern student of plant succession. The author states that: "The interpretations of past vegetations rests upon two basic assumptions. The first is that the operation of climatic and topographic forces in moulding plant life has been essentially the same throughout the various geological periods. This is a direct corollary of the conclusions of Lyell as to geology, and of Huntington, Humphreys and others as to climatology. The second assumption is the one already quoted, namely, that the operation of succession as the developmental process in vegetation has been essentially uniform throughout the whole course of the geosere. From these two assumptions naturally follows a third to the effect that the responses of animals and man to climate and to vegetation, both as individuals and in groups, have remained more or less identical throughout geological time. As a consequence of Darwin's work, this has long been accepted for the individual, but as to the community it still awaits detailed confirmation by the new methods of zoecology. Further, if all these be accepted as necessary working hypotheses, it is evident that what is true of the parts must be true of the whole plexus of geological causes and biological responses in the past."

The attempt is then made to trace the successions through the various geological eras with their shifting climates and climaxes. But here again the details are so numerous and so many biological principles are involved that only first-hand examination of these chapters can give the reader an adequate conception of the matter handled in this way. In passing it is interesting to note that Clements has used vegetation rather than animal life as the basis for the recognition of eras of the geological record, somewhat after the fashion of Saporta (1881). Thus we read: Eophytic, Paleophytic, Mesophytic, Cenophytic.

These latter chapters should be particularly suggestive and stimulating to the animal ecologist and the paleo-ecologist as well as to others with an interest in the phenomena of living thing of past ages.

The bibliography of nearly a thousand titles, the most of which have been abstracted or noted somewhere in the text, is still another valuable part of the book. This is probably the most nearly complete collection of titles on succession and related phenomena available.

It may be said, after securing a bird's-eye view of the book as a whole, that Clements's monograph presents an invaluable summary of our knowledge of plant succession and that it must become at once the indispensable reference and guide for the student of vegetative cycles in all parts of the world.

RAYMOND J. POOL
THE UNIVERSITY OF NEBRASKA

SPECIAL ARTICLES

RECENT INVESTIGATIONS OF TRACTIVE RESISTANCES TO MOTOR TRUCKS ON ROADS AND PAVEMENTS

AN experimental investigation was carried on in the research division of the electrical engineering department, at the Massachusetts Institute of Technology, during the year 1915, under a fund contributed for researches on motor trucks, for the purpose of determining the tractive resistance of a motor delivery wagon with four wheels and solid rubber tires on various level urban roads and pavements. The complete report on this research was published in the *Proceedings of the American Institute of Electrical Engineers,* June, 1916.

By "tractive resistance" is meant the horizontal force necessary to apply to the truck in order to keep it at a constant speed in still air after deducting axle frictions and internal-mechanism losses. It is, therefore, the reactive force offered by the truck, assumed

internally frictionless, in overcoming the road, tire and still-air resistances on a level surface. It may be expressed either in pounds weight per short ton of total moving mass, or in kilograms per metric ton, or in per cent. equivalent grade. Thus a 1 per cent. equivalent grade tractive resistance means that a car without axle friction or other internal mechanism losses would require to be pulled on a level road at a constant stated speed a force of 20 pounds per short ton of 2,000 pounds, in order to overcome the resistance of the tires, road-bed and still-air displacement. This force would obviously serve to propel the same vehicle up a 1 per cent. grade in the absence of tire, road-bed, still-air and internal frictions. At a given speed, therefore, this tractive resistance depends upon the wheel, the tire, and the road, and also on the air-displacement resistance of the truck.

The truck tested was a 1,000-lb. (450 kg.) electrically-propelled delivery wagon equipped with single solid rubber tires, one on each of the four wheels—the tire rating being 36 in. by 2½ in. (915 mm. by 63.5 mm.). The tests were made by running the car at, as nearly as possible, constant measured speed, in alternate directions, over selected lengths of standard roads in and near Boston. From the observed storage-battery outputs during these runs, the corresponding tractive resistances were evaluated after correcting for all losses internal to the truck mechanism, wind losses, grade and incidental accelerations. The internal losses of the truck mechanism from battery terminals to wheel spokes were determined from laboratory tests with the car raised from the ground on jacks, and by driving tested dynamos from the rear wheels.

The following is a summary of the results obtained as applying to urban roads with this truck between the speed limits of from 13 to 25 km. per hour (8 to 15.5 miles per hour).

1. The over-all efficiency of the test-truck mechanism between battery terminals and rear-wheel treads reached a maximum value of about 78 per cent., under the most favorable conditions.

2. The mechanical efficiency of transmission from motor shaft to rear-wheel treads, for the truck tested, shaft-driven through a single-reduction worm gear, was found as high as 90 per cent.

3. Under the conditions of these tests, the tractive resistance on level roads, in the absence of wind, is composed of (*a*) displacement resistance, (*b*) impact resistance and (*c*) air resistance.

By "displacement resistance" is meant that portion of the tractive resistance which depends on the lack of resilience of a smooth road surface and of the wheel-tire material; *i. e.*, on the energy losses due to inelastic displacement of tire and road-surface materials.

By "impact resistance" is meant that portion of the tractive resistance which depends on the lack of smoothness of the road surface, and which is due to the impacts given to the moving vehicle by the irregularities of the road.

By "air resistance" is meant that portion of the tractive resistance due to air pressure on the moving vehicle necessary to displace the air in the absence of wind.

4. The displacement resistance varied from 0.85 per cent. equivalent grade, for a hard smooth asphalt or bituminous concrete, to 1.6 per cent. for a very soft tar-macadam road, and was practically constant, for all speeds considered, on any given road.

5. The impact resistance increases with the velocity, with the total weight of vehicle, and with increasing road-surface roughness. In these tests, the impact resistance of good asphalt or bithulithic or other smooth pavement, was practically negligible, and reached its highest values (about 1.5 per cent. equivalent grade at a speed of 20 km. per hr. (12.4 miles per hr.) on granite-block roads with sand filled joints, and on badly worn macadam pavements. The rate of increase of impact resistance with speed was most marked on the roughest roads.

6. At the vehicle speed of 20 km. (12.4 miles) per hour, the air resistance for the vehicle tested, assumed to be dependent only on the speed, was roughly 0.11 per cent. equivalent grade; *i. e.*, from 4 per cent. of the high-

est, to 12.5 per cent. of the lowest, total tractive resistance.

7. The following urban pavements are enumerated in the order of their desirability for vehicle operation from the point of view of tractive resistance at 20 km. (12.4 miles). per hr., as found in this investigation. (1) asphalt, (2) wood block, (3) hard smooth macadam, (4) brick block, (5) granite block with cement-filled joints, (6) cinder, (7) gravel, (8) granite block with sand-filled joints.

8. The equivalent grade at 20 km. (12.4 miles) per hr. of a badly worn city macadam road, was found to be nearly three times as great as that of the best asphalt road tested. This means, at this speed, a consumption of energy at wheel treads, of nearly three times as much on level poor macadam roads as on good level asphalt roads.

9. Increasing the gross weight of the vehicle by 12 per cent. through load, was found to have no effect on tractive resistance within the observed speed limits for smooth roads in good condition; but on rough roads, a distinct increase in tractive resistance with this extra weight was observed.

10. The presence of a layer of dust, say one cm. thick, on a fair macadam road, was found to increase the equivalent grade of tractive resistance, at a speed of 20 miles (12.4 km.) per hr., from 1.17 to 1.32 per cent.

11. A freshly tarred and therefore very soft tar-macadam road was found to have an increased tractive resistance equivalent grade, at substantially all tested speeds, of about 0.5 per cent. The tires in this case sank about 0.8 inch (2 cm.) into the road-bed, the gross car weight being 2,140 kg. (4,710 lb.).

12. The total range of tractive resistance equivalent grade covered in the tests, was from 0.93 per cent. on the best asphalt road, at lowest speed, to 2.7 per cent. on the worst macadam road, at nearly the highest speed.

13. The results indicate, as has already been pointed out by other observers, the importance of constructing and maintaining smooth, hard and clean roads, from the point of view of tractive resistance. Low tractive resistance means small gasoline consumption for gasoline trucks, and a reduced electricity expense or greater daily mileage with electric trucks.

14. Other problems which are of practical importance to vehicle designers and operators, and which require further investigation are the following:

(*a*) Tractive resistances on country roads.

(*b*) Tractive resistances to vehicles with different wheel tires.

(*c*) Tractive resistances of urban roads at low speeds from 0 to 10 miles per hour (16 km. per hr.).

(*d*) Tractive resistances at speeds higher than 15 miles per hour (24 km. per hr.).

(*e*) Tractive resistances for high-capacity trucks.

15. The results of the tests here reported have been found to be in substantial agreement with those obtained by other observers employing somewhat different methods; but the analysis of tractive resistance into its components here presented appears to be new, and is recommended for use in similar investigations or tests.

16. The writers are indebted to Mr. Thomas A. Edison and also to the Gould Storage Battery Co. for funds by which the research was made possible.

A. E. KENNELLY,
O. R. SCHURIG
MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
CAMBRIDGE, MASS.

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 563d meeting of the society was held in the assembly hall of the Cosmos Club, Saturday, January 13, 1917, called to order by President Hay at 8 P.M., with 45 persons in attendance.

On recommendation of the council Dr George W. Field, Biological Survey, was elected to membership.

President Hay announced the membership of the Publication Committee; C. W. Richmond, J. H. Riley, Ned Dearborn, W. L. McAtee; and the membership of the committee on communications: Wm. Palmer, Alex. Wetmore, R. E. Coker, L. O. Howard, A. S. Hitchcock.

Under the heading of brief notes W. L. McAtee and Alex. Wetmore called attention to the presence

of white-winged crossbills in the vicinity of Washington, constituting the second authentic record of this species in the District fauna. The first specimen was seen by Mr. McAtee on December 10, 1916, in a flock of American crossbills. Later other specimens were seen on December 24, 27 and 30, as single birds and also in flocks, Mr. Wetmore having seen as many as forty birds together.

In contrast to this unusual northern visitor Mr. McAtee mentioned the lingering of summer birds, having noted a Cape May warbler on December 6, and a bluegray gnatcatcher about two weeks ago. He also mentioned having found a box turtle out and active on January 7, 1917.

Mr. E. A. Goldman mentioned the reported occurrence of Hudsonian chickadees in the vicinity of New York City and Boston.

Mr. A. S. Hitchcock called attention to the unusual precautions that were being taken in the care of the herbarium of the British Museum.

The regular program was as follows:

Some European Experiences with Entomologists: L. O. Howard.

Under the above title Dr. Howard read three short papers, entitled (a) "Rennes and René Oberthür," (*b*) "An Entomological Trip to the Crimea," and (*c*) "The Episode of Theophile Gautier," all illustrated with lantern slides. In the first he described the personality of René Oberthür, one of the great amateur collectors of insects in Europe, and his beautiful place at Rennes where he has a private museum, an extraordinary arboretum, and one of the largest collections of orchids in existence. He spoke at some length of the very important voluntary assistance which M. Oberthür had given the Bureau of Entomology in the collection and importation of the parasites of the gipsy moth and the brown-tailed moth from Europe into the United States, and gave an account of an automobile journey through Brittany and Normandy in the summer of 1909, on which he was accompanied by M. Oberthür and by Paul Marchal, of the Station Entomologique de Paris.

In the second paper he described a journey from Budapest through Lemburg to Kiew in 1907, the establishment of an experimental station at Kiew under the direction of Professor Waldemar Pospielow, of the University of Kiew, of the journey thence to Sebastopol, Bachtisserai and Simferopol; of the regional museum at the latter place under the charge of Professor Sigismond Mokshetsky, and of the excellent work in economic entomology done by Professor Mokshetsky in the Crimea. He also mentioned the old palace of the Khan of the Crimea at Bachtisserai and the marine zoological laboratory at Sebastopol.

In the concluding episode he described his personal experiences in 1910 and 1912 with Theophile Gautier, one of the most successful rose-growers of France, at Angiers, a man of the simplest appearance and habits but of the highest standing in horticultural circles and an *Officier* of the order of *Mérite Agricole.*

Recent Additions to the List of North American Birds: H. C. Oberholser.

Dr. Oberholser said that the period from 1910 to 1916, inclusive, was one of great ornithological activity. During this period fully 125 species and subspecies were added to the list of birds known from North America. Most of these additions resulted from the description of new subspecies or the revival of hitherto unrecognized forms, which together amount to over 100, among the most interesting being five new subspecies from Newfoundland. Two distinct species were described from North America during this time: *Æstrelata cahow* from the Bermuda Islands, and a remarkable new gull, allied to *Larus californicus,* called *Larus thayeri,* from Ellesmere Land. Also a number of extra limital forms were for the first time detected within our boundaries, among the most notable of which might be mentioned *Puffinus carneipes* taken in California; *Totanus totanus* from Greenland; *Calliope calliope camtschatkensis* and *Hypocentor rusticus,* both from Kiska Island, Alaska; *Nyroca ferina, Marila fuligula, Clangula clangula clangula, Cryptoglaux funerea funerea, Coccothaustes coccothaustes japonicus,* and *Fringilla montifringilla,* all from the Pribilof Islands; *Pœcilonetta bahamensis* from Florida; *Petrochelidon fulva pallida* from Texas; and *Tyrannus melancholocus satrapa* from Maine.

The Fossil Seacow of Maryland: Wm. Palmer.

Mr Palmer exhibited the fifth thoracic neural arch of a sirenian which was shown to be unlike that of the manatee and to agree absolutely, except in size, with a similar bone of Steller's seacow (*Hydrodamalis*) from Bering Sea. The specimen was found, freshly fallen, under a cliff of the Calvert Miocene on the western shore of Maryland. It was suggested that the species was living during the period following the first erosion of the Cretaceous and the deposition of the Eocene as all the specimens so far found in the Miocene were clearly redeposits from an earlier age.

M. W. Lyon, Jr.,
Recording Secretary